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RTCC REQUIREMENTS FOR APOLLO 11 (MISSION G) PREFLIGHT INFORMATION

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MISSION PLANNING AND ANALYSIS DIVISION

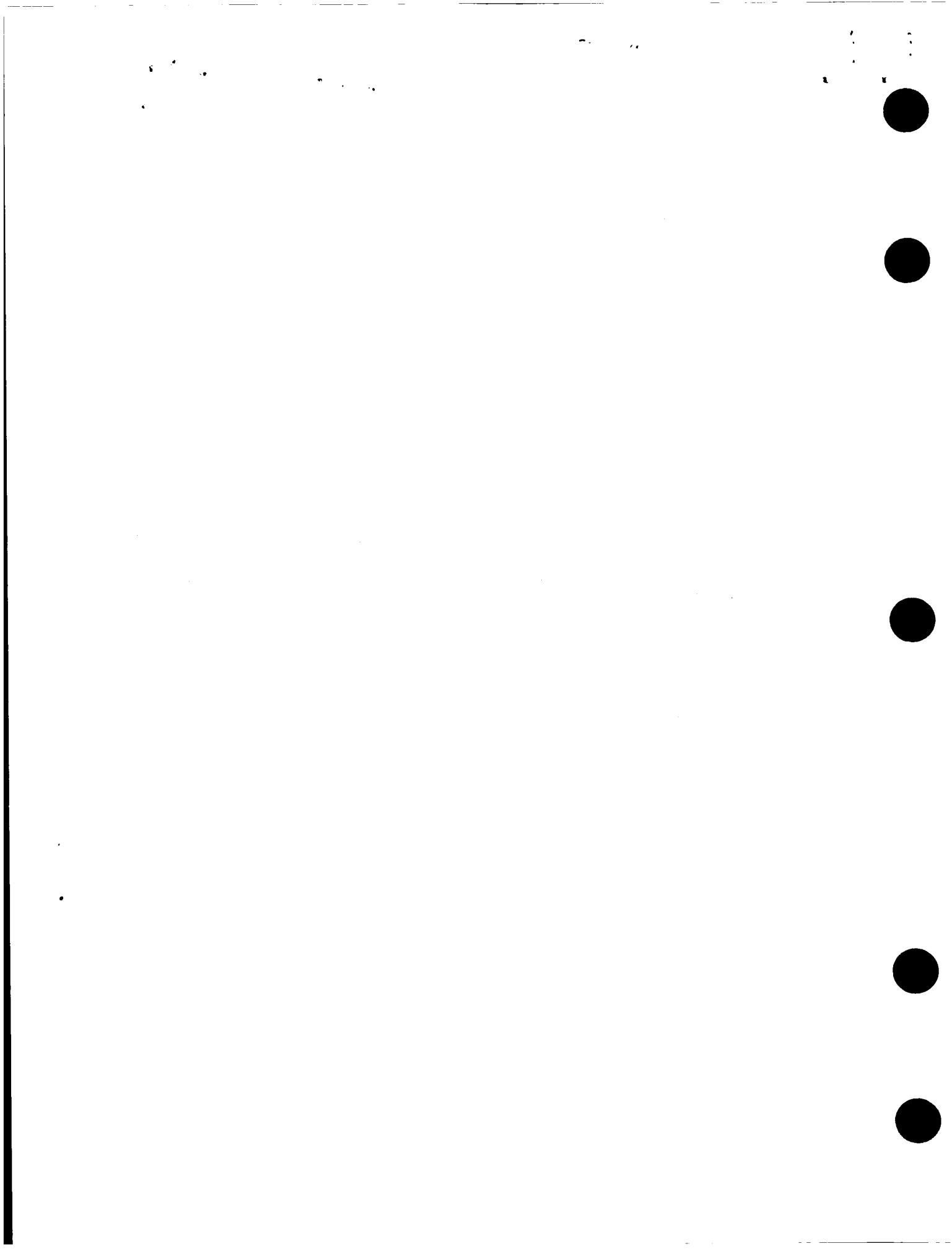
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(NASA-TM-X-69625) RTCC REQUIREMENTS FOR
APOLLO 11 (MISSION G) PREFLIGHT
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RTCC REQUIREMENTS FOR APOLLO 11

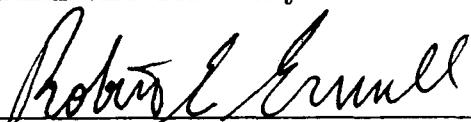
(MISSION G) PREFLIGHT INFORMATION

By Rocky D. Duncan

Change 1

June 27, 1969

Ronald L. Berry, Chief
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John P. Mayer, Chief
Mission Planning and Analysis
Division

fa Page 1 of 2
(with enclosures)

After the following pen and ink changes have been made, insert this sheet after the cover page and write on the front, "CHANGE 1 inserted".

1. On page 8, change the following:

Under T_{\min} sea

July 16 104.5 hrs should be 105.0 hrs
July 18 101.5 hrs should be 106.0 hrs
July 21 110.0 hrs should be 114.0 hrs

Under T_{\max} sea

July 16 123.0 hrs should be 122.5 hrs
July 18 123.0 hrs should be 123.5 hrs
July 21 123.0 hrs should be 131.5 hrs

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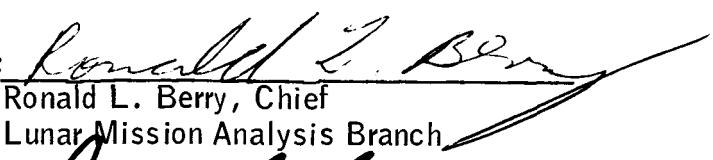
PROJECT APOLLO

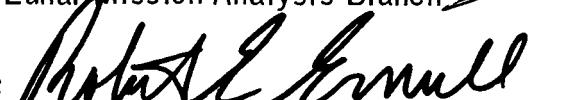
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(MISSION G) PREFLIGHT INFORMATION

By Rocky D. Duncan
Lunar Mission Analysis Branch

June 24, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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RTCC REQUIREMENTS FOR APOLLO 11 (MISSION G)

PREFLIGHT INFORMATION

By Rocky D. Duncan

SUMMARY AND INTRODUCTION

The purpose of this document is to present the preflight data requirements for direct support of the RTCC programs for Apollo 11 (Mission G). The information applies only to those processors formulated by the LMAA. The processors for which preflight information has been defined are as follows.

1. TLI processor
2. MCC processor
3. Return-to-earth processor
4. LOI processor
5. Powered-flight processor

SYMBOLS

CSM	command and service modules
DPS	descent propulsion system
EMP	earth-moon plane
FCUA	fuel-critical unspecified area
LLS	lunar landing site

LM	lunar module
LMAB	Lunar Mission Analysis Branch
LOI	lunar orbit insertion
LOPC	lunar orbit plane change
LPO	lunar parking orbit
MCC	midcourse correction
MPT	mission planning table
n.d.	nondimensional
opp	opportunity
RTCC	Real-Time Computer Complex
SPS	service propulsion system
TEI	transearth injection
TLI	translunar injection
TLMC	translunar midcourse correction

TRANSLUNAR INJECTION AND MIDCOURSE CORRECTION PROCESSORS^a

This section describes the parameters, coefficients, and constants associated with the TLI and MCC processors. Most of the preflight data defined in this section is used by both processors; consequently, both processors are treated as a single entity. Definitions of the individual parameters and constants are presented in table I.

The TLI and MCC processors require the largest share of the preflight data requirements. Most of these requirements are the parameters which vary with launch azimuth, injection opportunity, and launch day across a monthly launch window. These numbers are dependent and independent variables which constitute all the first guesses and other numbers required to fly the mission. Because of the large number of parameters required, it has been decided to provide these data to IBM on tape.

The tape quantities were first punched on cards by the LMAB and then a card-to-tape process was used with IBM equipment. The purpose of this procedure is to avoid the difficulty of the differences in tapes generated by IBM and UNIVAC tape drives. The punched-card format and the order of the parameters are shown in table II. For each launch azimuth and injection opportunity, there is a data set on tape that consists of all the parameters required to fly that particular mission. The data sets will be ordered on the cards as follows.

1. Launch day
2. Launch azimuth
3. Second opportunity
4. First opportunity

The remainder of the preflight data (table III) which does not vary with launch day is provided by written transmittal.

RETURN TO EARTH PROCESSOR

The return to earth processor determines the maneuver required to produce trajectories which return to earth through use of state vectors in either moon or earth reference. The return to earth processor is described in references 3 and 4, and the constants, coefficients, and numbers associated with this processor are defined in table IV. These preflight data requirements can be functionally categorized as follows.

1. General constants
2. Generalized iterator constants
3. Guidance and targeting constants
4. Conic subprocessor constants

The preflight data for Apollo 11 (Mission G) are presented in tables V, VI, and VII.

LUNAR ORBIT INSERTION PROCESSOR

The LOI targeting processor computes several impulsive maneuvers to transfer from an approach hyperbola to a lunar parking orbit. A description of the lunar orbit insertion processor can be found in reference 5. The impulsive maneuvers transfer the spacecraft to different LPO's (such as an LPO with the minimum LOI ΔV or an LPO nearest the desired LPO). The flight controller selects the desired maneuver and transfers it to the MPT where the powered-burn targets are computed and the guidance is selected.

The preflight data requirements for the LOI processor are presented in table VIII. The actual values are presented in table IX. Note that most of the LOI processor data requirements are contained in the MCC data tables.

POWERED-FLIGHT PROCESSOR

The parameters and constants associated with the powered-flight processor (ref. 6) are described in this section. The powered-flight processor simulates thrusting maneuvers in the RTCC. The associated parameters and constants are principally the guidance constants and targeting parameters associated with the iterative guidance equations and the hypersurface, respectively.

Because some of the powered-flight processor preflight data varies with launch azimuth, injection opportunity, and launch day, it was decided to provide these data on tape. This arrangement is convenient because these data are provided to MSC by MSFC in the launch vehicle PRESET tape.

LMAB will verify the numbers on the PRESET tape and generate cards for delivery to IBM. A card-to-tape process will be used to generate an IBM tape.

All of the parameters and constants used by the powered-flight processor are defined in table X. The format for the PRESET tape is presented in table A-I, and the format for the cards delivered to IBM is presented in table A-II. This card format allows for up to a 10-day monthly launch window.

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS

ASSOCIATED WITH THE TLI AND MCC PROCESSORS

No.	Parameter or constant	Processor utilizing parameter		Parameter or constant on tape	Definition
		TLI	MCC		
1	$T_{\text{LI ign}}$	X		Yes	Ground elapsed time of translunar injection ignition
2	δ	X		No	Declination of target vector for alternate missions
3	σ	X		No	Perigee ring half-angle for alternate missions
4	$T_{\text{max sea}}$		X	No	Maximum G.m.t. of pericynthion due to sun elevation constraints
5	$T_{\text{min sea}}$			No	Minimum G.m.t. of pericynthion due to sun elevation constraints
6	γ_{loi}		X	Yes	Flight-path angle at lunar orbit insertion initiation
7	$\Delta\psi_{\text{loi}}$		X	Yes	Change in azimuth at lunar orbit insertion
8	H_{pc}	X	X	Yes	Height of pericynthion
9	ϕ_{pc}	X	X	Yes	EMP latitude at pericynthion
10	λ_{pc}	X	X	Yes	EMP longitude at pericynthion
11	GMT_{pc}		X	Yes	G.m.t. time of pericynthion from epoch
12	ΔT_{lls}		X	Yes	Flight time from lunar orbit insertion to first pass over lunar landing site
13	T_{lo}		X	Yes	Total time spent in lunar orbit
14	ϕ_{lls}		X	Yes	Selenographic latitude of the lunar landing site
15	λ_{lls}		X	Yes	Selenographic longitude of lunar landing site
16	R_{lls}		X	Yes	Radius of the lunar landing site
17	ψ_{lls}		X	Yes	Selenographic azimuth over the lunar landing site
18	$I_{\text{fr(max)C}}$	X	X	No	Conic inclination of the free-return trajectory plus ΔI_{fr}
19	$I_{\text{fr(max)T}}$			No	Integrated inclination of the free-return trajectory plus ΔI_{fr}

TABLE I.- DEFINITION OF PARAMETERS AND CONSTANTS

ASSOCIATED WITH THE TLI AND MCC PROCESSORS - Concluded

No.	Parameter or constant	Processor utilizing parameter		Parameter or constant on tape	Definition
		TLI	MCC		
20	ΔV_{tei}		X	Yes	Change in velocity at TEI (scalar)
21	$\Delta \psi_{tei}$		X	Yes	Change in azimuth at transearth injection
22	T_{te}		X	Yes	Time from transearth injection to entry
23	Rnty Rng		X	No	Inertial entry range
24	Rnty Δt		X	No	Delta t from entry to drogue
25	h_{rtny}	X	X	No	Height at entry for free return
26	γ_{rtny}	X	X	No	Flight-path angle at entry
27	I_{pr}		X	No	Maximum inclination for powered return
28	λ_{ip}		X	No	Longitude of earth impact point
29	$T_{tl \text{ min dps}}$		X	No	Minimum translunar flight time for DPS abort
30	$T_{tl \text{ max dps}}$		X	No	Maximum translunar flight time for DPS abort
31	$m \}$				Number required to compute the CSM plane change prior to LM ascent
32	$n \}$		X	No	
33	T_{biaseo}		X	No	Bias time for elliptical lunar parking orbit
34	V_{pcynlo}		X	No	Velocity at pericynthion of the elliptical lunar parking orbit
35	I_{fr}		X	Yes	Inclination of free return
36	Δt_{ndcir}		X	No	Delta t from the LPO node to circularization in the final LPO
37	H_{pc}		X	No	Height of pericynthion relative to the landing site of elliptical lunar parking orbit
38	H_{ac}		X	No	Height of pericynthion relative to the landing site of elliptical lunar parking orbit

TABLE II.- FORMAT FOR TLI AND MCC TAPE

Card no.	1 - 17	18 - 34	35 - 51	52 - 68	69 - 80
1	341	1	0.108E+03	P	693411108P1
(Day)	(Opportunity)	(Launch ψ)	(Window)		(Identification ^a)
2	0.351723E+01	0.16003591E+03	0.8015632E+02	0.2183654	693411108P2
(ϕ_{pc})	(λ_{pc})	(H_{pc})	(g.e.t. of TLI _{igen})		(Identification ^a)
3					693411108P3
					(Identification ^a)
4	0.418363E+01	-0.113801956E+01	0.685321E+02	0.2631562E+02	693411108P4
($\Delta\Phi_{1oi}$)	(γ_{1oi})	(T_{1o})	(ΔT_{1ls})		(Identification ^a)
5	0.7253621E+02	0.10300852E+01	0.45056623E+02	0.938E+02	693411108P5
(Ψ_{1ls})	(Φ_{1ls})	(λ_{1ls})	(R_{1ls})		(Identification ^a)
6	-0.31044682E+01	0.276191422E+04	0.103856155E+02	0.173E+02	693411108P6
($\Delta\Phi_{tei}$)	(ΔV_{tei})	(T_{te})	(I_{fr})		(Identification ^a)
7	108.3E + 03	RESERVED FOR EXPANSION			
(G.m.t. of pc)					
8		RESERVED FOR EXPANSION			

^aThe identification number has the following parts:

Year	693411108P1	Card number
Day		Injection window
Opportunity		Launch azimuth

TABLE III.- VALUES FOR VARIABLES NOT FOUND ON TAPE

Variable	Value
δ	0.0°
σ	7.5°
T_{\min} sea	
July 16	104.5 hrs 105.0 hrs
July 18	101.5 hrs 106.0 "
July 21	110.0 hrs 114.0 "
T_{\max} sea	
July 16	123.0 hrs 122.5 hrs
July 18	123.0 hrs 123.5 hrs
July 21	126.0 hrs 131.5 hrs
$I_{fr(max)C}$	75°
$I_{fr(max)I}$	90°
H_{rnty}	400 000 ft
Rnty Rng	1380 n. mi.
Rnty Δt	500 sec
γ_{rnty}	-6.52°
I_{pr}	40°
λ_{ip}	170° W
$T_{tl \ min \ dps}$	1 hrs
$T_{tl \ max \ dps}$	100 hrs
m	3
n	8
T_{biaseo}	.332 hr
V_{pcynlo}	5480.0 fps
Δt_{ndcir}	4.3 hr
H_{pc}	60 n. mi.
H_{ac}	170 n. mi.

TABLE IV.- RETURN TO EARTH ABORT PROCESSOR CONSTANTS TAPE LIST

Variable symbol	Variable definition
(a) General constants	
e_{LIM}	Eccentricity limit for EFCUA
MD_{MAX}	Maximum miss distance used in the trade-off displays
ΔMD	Miss distance increment used in the trade-off displays
$R_A MAX$	Abort radius limit for the EFCUA solution in the FCUA mode of the earth phase logic
T_{ARMIN}	Absolute minimum acceptable flight time from abort to entry
(b) Generalized iterator constants	
Tol_j $j = 1, 6$	Dependent variable tolerances
AVO, BVO	Two constants used to determine the minimum and maximum value for $ \Delta V $ in the optimise mode: Minimum = Maximum = MAX [AVO, (conic value) - BVO]
$STPZ_j$ $j = 1, 10$	Step sizes for the independent variables
$IWGT_j$ $j = 1, 11$	Independent variable weights
$DWGT_j$ $j = 1, 2$	Dependent variable weights

TABLE IV.- RETURN-TO-EARTH ABORT PROCESSOR

CONSTANTS TAPE LIST - Continued

Variable symbol	Variable definition
(c) Guidance and targeting constants	
C_{NOMC}	Nominal value of CM computer guidance parameter C
C_{NOML}	Nominal value of LM computer guidance parameter C
R_{TSPH}	Radius of the MSI used by the onboard guidance computer
TB_{SPS}	Maximum burn time for the SPS engine with no iteration in RTED
TB_{DPS}	Maximum full thrust level burn time for the DPS engine with no iteration in RTED
β_{LTST}	Limiting value of flight-path angle between \bar{R} and \bar{V} for solutions from Lambert's problem subroutine with the Lambert's guidance
ΔT_{LTG}	Time increment used in lunar reference to generate Lambert target vectors
ϵ_{TG}	Lambert's guidance target vector bias angle
η_{ATG}	Alternate transfer angle to Lambert's guidance target vector in earth reference
η_{MTG}	Transfer angle to Lambert's guidance target vector in moon reference
(d) Earth-centered subprocessor	
δT_z	Landing time tolerance for input landing time in the AST discrete solution option
$a \left. \begin{matrix} \\ b \\ c \end{matrix} \right\}$	Coefficients for the landing time limit function

TABLE IV.- RETURN-TO-EARTH ABORT PROCESSOR

CONSTANTS TAPE LIST - Concluded

Variable symbol	Variable definition
(d) Earth-centered subprocessor - Concluded	
T_{RZAVE}	Average flight time from entry to landing
η_{RZAVE}	Average down-range angle from entry to landing
(e) Moon-center subprocessor	
ΔT_z	Value of the maximum trip time whenever the maximum landing time is not input for the FCUA option of the AST

TABLE V.- VALUES FOR GENERAL CONSTANTS AND
GUIDANCE AND TARGETING CONSTANTS

Variable	Value
e_{LIM}	0.85
MD_{MAX}	400 n. mi.
ΔMD	100 n. mi.
R_{AMAX}	140 000 n. mi.
T_{ARMIN}	20 min
C_{NOMC}	0.5
C_{NOML}	0.0
R_{TSPH}	64 373 760 m
TB_{SPS}	15 sec
TB_{DPS}	15 sec
β_{LTST}	2°
ΔT_{LTG}	2 hr
ϵ_{TG}	15°
η_{ATG}	215°
η_{MTG}	160°

TABLE VI.- VALUES FOR GENERALIZED ITERATOR CONSTANTS

Constant tape symbol	Associated iterator variable	Value
Tol ₁	h_R	0.03 n. mi.
Tol ₂	Ψ_R	2°
Tol ₃	ϕ_Z	0.10°
Tol ₄	λ_Z	0.01°
Tol ₅	γ_R	0.001°
Tol ₆	T_{AZ}	12 hr
AVO	$ \overline{\Delta V} $	-10 000 fps
BVO	$ \overline{\Delta V} $	10 000 fps
STPZ ₁	$\Delta \Psi_A$	1×10^{-6} rad
STPZ ₂	$\Delta \gamma_A$	1×10^{-6} rad
STPZ ₃	ΔV_A	2×10^{-7} er/hr
STPZ ₄	T_A	1×10^{-7} hr
STPZ ₅	T_R	1×10^{-6} hr
STPZ ₆	ΔV_X	1×10^{-7} er/hr
STPZ ₇	ΔV_Y	1×10^{-7} er/hr
STPZ ₈	ΔV_Z	1×10^{-7} er/hr
STPZ ₉	$\Delta \gamma_A$ (optimise setup)	1×10^{-6} rad
STPZ ₁₀	ΔV_A (optimise setup)	2×10^{-7} er/hr
IWGT ₁	$\Delta \Psi_A$	1
IWGT ₂	$\Delta \gamma_A$	1

TABLE VI.- VALUES FOR GENERALIZED ITERATOR CONSTANTS - Concluded

Constant tape symbol	Associated iterator variable	Value
IWGT ₃	$\Delta\gamma_A$ (optimise setup only)	1
IWGT ₄	ΔV_A	16
IWGT ₅	ΔV_A (optimise setup only)	1
IWGT ₆	T_A (standard setup)	64
IWGT ₇	T_A (RTED)	1
IWGT ₈	T_R	1
IWGT ₉	ΔV_X	1
IWGT ₁₀	ΔV_Y	1
IWGT ₁₁	ΔV_Z	1
DWGT ₁	T_{AZ}	1
DWGT ₂	$ \overline{\Delta V} $	200

TABLE VII.- CONIC SUBPROCESSOR

Symbol	Value
(a) Earth-centered subprocessor	
δT	2 hr
a	77.0 hr
b	+6.2 hr/er
c	-0.103333 hr/er ²
T_{RZAVE}	0.14 hr
n_{RZAVE}	0.5 rad
(b) Moon-centered subprocessor	
ΔT_Z	120 hr

TABLE VIII.- PREFLIGHT PARAMETERS FOR LOI PROCESSOR

Symbol	Definition
H_{lo}	Nominal LPO circular orbit altitude referenced to the LLS
H_{ac}	Nominal LPO elliptical orbit apocynthion altitude referenced to the LLS
O_{eo}	Number of revolutions in elliptical LPO
ϕ_{lls}^a	Latitude of LLS
λ_{lls}^a	Longitude of LLS
R_{lls}^a	Radius of LLS
$\begin{matrix} m \\ n \end{matrix} \}$	Numbers used to compute CSM plane change
$\Delta V_{loi\ cal}$	Calibration of conic LOI ΔV
$\Delta V_{tei\ cal}$	Calibration of conic TEI ΔV
c	First guess on Lambert guidance constant
Transfer angle	Transfer angle from LOI impulsive point to Lambert target vector
H_{rnty}	Nominal value for height of reentry
I_{pr}^a	Nominal value for inclination of powered return
T_{te}^a	Nominal transearth flight time
T_{lo}^a	Time in lunar parking orbit
ΔT_{lls}^a	Delta time to first pass over LLS
ΔV_{tei}^a	Delta velocity at TEI

^aThe parameters are on the MCC preflight data tape.

TABLE VIII.- PREFLIGHT PARAMETERS FOR LOI PROCESSOR - Concluded

Symbol	Definition
$\Delta\psi_{tei}^a$	Delta azimuth at TEI
GMT_{pc}^a	Greenwich mean time of pericynthion measured from epoch

^aThe parameters are on the MCC preflight data tape.

TABLE IX.- LOI PREFLIGHT DATA NOT CONTAINED IN
MCC PROCESSOR DATA TABLES

Symbol	Value
H_{lo}	60 n. mi.
H_{ac}	170 n. mi.
θ_{eo}	2
m	3
n	8
$\Delta V_{loi\ cal}$	10 fps
$\Delta V_{tei\ cal}$	0 fps
c	.5
Transfer angle	270°
H_{rnty}	400 000 ft

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM)

Parameter	Definition	Value
$K_{\alpha 1}, K_{\alpha 2}$	coefficients of α_{TS} polynomial	0, 0
DTGM	time from TB_6 to time at which IGM guidance is initiated	584.0 sec
DTIG	time from TB_6 to time at which ignition occurs	578.0 sec
K_{po}, K_{yo}	coefficients in pitch, yaw polynomials	90.0, 0.0 deg
K_{T3}	coefficient in T_3 polynomial	0.0
T_2	second guidance stage burn time	{ 111.0 sec (first opp) 0.0 sec (second opp)
t_{b2}	transition time for mixture ratio shift	{ 5.0 sec (first opp) 1.0 sec (second opp)
K_{pc}	constant used to force MRS in IGM	0.0 sec
ϵ_1	remaining burn time for which alternate method of computing range angle is used	1000. sec
ϵ_2	remaining burn time for which guidance enforces only terminal velocity conditions	30. sec
ϵ_3	remaining burn time for which terminal r, v, γ are frozen	30. sec
ϵ_4	remaining burn time at which cutoff equations are entered	3. sec
RdT	flag which indicates rotation of end conditions	1.0
RdV	constant used for biasing terminal range angle prediction	-0.4
\dot{x}_{YL}	maximum allowable pitch rate	1.0 deg/sec
\dot{x}_{ZL}	maximum allowable yaw rate	1.0 deg/sec
\dot{x}_{XL}	maximum allowable roll rate	1.0 deg/sec
C'_o	time artificial tau mode is used, measured from time IGM is initiated	10.0 sec
ΔT_{4M}	limited value for difference between actual and nominal burn times for first S-IVB burn	100.0 sec
V_{EX3}	exhaust velocity, third IGM stage	{ 4198.1678 m/sec (first opp) 4201.5453 m/sec (second opp)
τ_{2N}	estimated time to deplete vehicle mass, second IGM stage	{ 722.67 sec (first opp) 629.40 sec (second opp)

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM) - Continued

Parameter	Definition	Value
\dot{M}_3	mass flow rate, third IGM stage	{ 472.159 lb/sec (first opp) 472.760 lb/sec (second opp)
	S-IVB engine model	
T_0	time from TB_6 to start of first thrusting phase (vent and ullage)	0.0 sec
T_1	time from TB_6 to start of second thrusting phase (chilldown)	570.0 sec
T_2	time from TB_6 to start of third thrusting phase (buildup)	578 sec
T_3	time from TB_6 to start of fourth thrusting (main burn)	580.5 sec
T_{MRS}	time from TB_6 to mixture ratio shift (first opp only)	695.5 sec
DTT	delta time from cutoff for J2 tailoff phase	1.80 sec
DTV	delta time for LH2 vent	592 sec
TH0	thrust level in first phase	38.8 lb
TH1	thrust level in second phase	5889 lb
TH2	thrust level in third phase	110 900 lb
TH3L	thrust level in fourth phase (first opp pre-MRS)	178 147 lb
TH3H	thrust level in fourth phase (first opp post-MRS)	202 097 lb
TH3	thrust level in fourth phase (second opp)	202 256 lb
THTO	thrust level in tailoff phase	27 784 lb
THV	thrust level in tailoff vent phase	12.0 lb
MFO	mass flow rate, first phase	.111 lb/sec
MF1	mass flow rate, second phase	.750 lb/sec

TABLE X.- PREFLIGHT CONSTANTS (DATA) - (POWERED FLIGHT PROCESSOR - IGM) - Concluded

Parameter	Definition	Value
MF2	mass flow rate, third phase	157.6 lb/sec
MF3L	mass flow rate, fourth phase (first opp, pre-MRS)	412.167 lb/sec
MF3H	mass flow rate, fourth phase (first opp, post-MRS)	472.121 lb/sec
MF3	mass flow rate, fourth phase (second opp)	472.180 lb/sec
MFTO	mass flow rate, tailoff phase	61.7 lb/sec
MFV	mass flow rate, tailoff vent phase	.209 lb/sec

APPENDIX

TAPE FORMAT FOR THE POWERED-FLIGHT PROCESSOR

TABLE A-I.- MSFC PRESENT TAPE FORMAT

Tape position	Symbol	Units	Definition (reference)
1		days	Launch day
2		months	Launch month
3		years	Launch year
4	TLO	sec	Reference launch time (midnight)
5	RAO (θ_{EO})	deg	Reference launch site right ascension (positive east of vernal equinox)
6			Blank
7			Blank
8 - 60	A _Z	deg	Table of values for launch azimuth from analytic launch azimuth model
61 - 113	t _D	sec	Table of values for t _D corresponding to values of A _Z
114 - 128	RAS ₁	deg	15-place table of target vector right ascension, first TLI opportunity
129 - 143	DEC ₁	deg	15-place table of target vector declination, first TLI opportunity
144 - 158	C3 ₁	km ² /sec ²	15-place table of target C ₃ ₁ (twice specific energy at TLI), first TLI opportunity

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
159 - 173	$\cos \sigma_1$		15-place table of values of $\cos \sigma_1$, first TLI opportunity
174 - 188	e_{N_1}		15-place table of values of e_{N_1} , first TLI opportunity
189 - 190			Blank
191 - 205	RAS ₂	deg	Table of values of target vector right ascension, second TLI opportunity
206 - 220	DEC ₂	deg	Table of values of target vector declination, second TLI opportunity
221 - 235	C3 ₂	km ² /sec ²	Table of values of C3 ₂ (twice specific energy at TLI), second TLI opportunity
236 - 250	$\cos \sigma_2$		Table of values of $\cos \sigma_2$, second TLI opportunity
251 - 265	e_{N_2}		Table of values of e_{N_2} , second TLI opportunity
266			Number of azimuths
267			Blank

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
268 - 282	t_D	sec	Table of values of t_D , independent variable for all out-of-orbit targeting tables, both TLI opportunities
283	αTS_1	deg	Angle between \hat{S} and \hat{T} at S-IVB reignition, first opportunity
284	β_1	deg	Angle between \hat{S} and \hat{R}_i at initiation of S-IVB restart preparations, first opportunity
285	R_{N_1}	ft	Nominal reignition radius, first opportunity
286	T_{ST_1}	sec	Constant used to initiate the $\bar{S} \cdot \bar{T}_p$ test, first opportunity
287	f_1	deg	True anomaly of the predicted cutoff radius vector, first opportunity
288	$T'_{3R\perp}$	sec	Initial prediction of fifth stage (IGM) burn time, first opportunity
289	$\tau_{3R\perp}$	sec	Estimated time to deplete vehicle mass from assumed MRS, first opportunity
290	ΔV_{BR1}	m/sec	Velocity cutoff bias for translunar injection, first opportunity

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
291, 292			Blank
293	α_{TS_2}	deg	Angle between \hat{S} and \hat{T} at S-IVB reignition, second opportunity
294	β_2	deg	Angle between \hat{S} and \hat{R}_i at initiation of S-IVB restart preparations, second opportunity
295	R_M^2	ft	Nominal reignition radius, second opportunity
296	T_{ST2}	sec	Constant used to initiate the $\bar{S} \cdot \bar{T}_p$ test, second opportunity
297	f_2	deg	True anomaly of the predicted cutoff radius vector, second opportunity
298	T'_{3R2}	sec	Initial prediction of fifth stage (IGM) burn time, second opportunity
299	τ_{3R2}	sec	Estimated time to deplete vehicle mass from assumed MRS, second opportunity
300	ΔV_{BR2}	m/sec	Velocity cutoff bias for translunar injection, first opportunity
301 - 303			Blank

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Continued

Tape position	Symbol	Units	Definition (reference)
a ₃₀₄	AZO	deg	Initial value of launch azimuth used as independent variable in forming the polynomials for i and θ_N
305	AZS	deg	Range of launch azimuth values used in forming the polynomials for i and θ_N
306 - 312	f ₀ , f ₁ , • • • f ₆	n.d.	Coefficients of polynomial for i
313 - 319	g ₀ , g ₁ , • • • g ₆	n.d.	Coefficients of polynomial for θ_N
320 - 324	h ₁₀ , h ₁₁ , • • • h ₁₄	n.d.	Coefficients of first launch azimuth polynomial segment
325 - 329	h ₂₀ , h ₂₁ , • • • h ₂₄	n.d.	Coefficients of second launch azimuth polynomial segment
330 - 334	h ₃₀ , h ₃₁ , • • • h ₃₄	n.d.	Coefficients of third launch azimuth polynomial segment

^aData in tape positions 304 through 346 are not used by the Powered-Flight Processor.

TABLE A-I.- MSFC PRESENT TAPE FORMAT - Concluded

Tape position	Symbol	Units	Definition (reference)
335	t_{DS1}	sec	Time of closing of the first launch azimuth segment and opening of the second segment
336	t_{DS2}	sec	Time of closing of the second launch azimuth segment and opening of the third segment
337	t_{DS3}	sec	Time of the closing of the third launch azimuth segment
338	t_{D1}	sec	Actual time of launch minus referenced time of launch (TLO) opening of first azimuth polynomial segment
339	t_{D2}	sec	t_D at opening of second azimuth polynomial $t_{D2} = t_{DS1}$
340	t_{D3}	sec	Value of t_D at opening of third azimuth polynomial $t_{D3} = t_{DS2}$
341	t_{SD1}	sec	t_D increment over first azimuth polynomial segment = t_{DS1}
342	t_{SD2}	sec	t_D increment over second polynomial segment = $t_{DS2} - t_{DS1}$
343	t_{SD3}	sec	increment third segment = $t_{DS3} - t_{DS2}$
344 - 346			Blank

MSC CARD FORMAT

1. All numbers will be right justified in the field , except the ID which will be left justified.
2. All numbers except launch day and opportunity will be in a form such as X.XXXXXXXX or X.XXXXXXXX±XXX.
3. If there are no parameters for a launch day or opportunity, then all fields should be zero.
4. The values of t_D will be in ascending order.

5. Identification field:

XX	XXX	X	XXX
year	day of year		card number
opportunity			

TABLE A-II.- CARD FORMAT

Card no	Column
1	1 - 17 18 - 34 35 - 51 52 - 68 69 - 80
2	Launch day of year Opportunity t_D COS σ Identification
3	C_3 e_n RA DEC Hours
4	Er^2/hr^2 t_D COS σ C_3 e_n Identification
5	Er^2/hr^2 RA DEC t_D COS σ Identification
6 - 23	The format of cards 3, 4, and 5 will be repeated in cards 6 - 23
24 - 46	Same format as cards 1 - 23 except for the same launch day and second opportunity
47 - 92	Same format as cards 1 - 46 except for second launch day
93 - 138	Same format as cards 1 - 46 except for third launch day

TABLE A-II. - CARD FORMAT - Continued

Card no	Column										
139 - 184	Same format as cards 1 - 46 except for fourth launch day										
185 - 230	Same format as cards 1 - 46 except for fifth launch day										
231 - 276	Same format as cards 1 - 46 except for sixth launch day										
277 - 322	Same format as cards 1 - 46 except for seventh launch day										
323 - 368	Same format as cards 1 - 46 except for eighth launch day										
369 - 414	Same format as cards 1 - 46 except for ninth launch day										
415 - 460	Same format as cards 1 - 46 except for tenth launch day										
	1 - 17 18 - 34 35 - 51 52 - 68 69 - 80										
461	<table border="1"> <tr> <th>Launch day of year</th> <th>Opportunity</th> <th>T_{ST}</th> <th>•</th> <th>β</th> <th>XXXXXXX</th> </tr> </table>	Launch day of year	Opportunity	T _{ST}	•	β	XXXXXXX				
Launch day of year	Opportunity	T _{ST}	•	β	XXXXXXX						
462	<table border="1"> <tr> <td>α_{TS}^*</td> <td>f</td> <td>R_N</td> <td>T₃</td> <td>XXXXXXX</td> </tr> <tr> <td>Radians</td> <td>Radians</td> <td>Er</td> <td>Hours</td> <td>Identification</td> </tr> </table>	α_{TS}^*	f	R _N	T ₃	XXXXXXX	Radians	Radians	Er	Hours	Identification
α_{TS}^*	f	R _N	T ₃	XXXXXXX							
Radians	Radians	Er	Hours	Identification							
463	<table border="1"> <tr> <td>τ_{3R}</td> <td>T₂</td> <td>V_{ex2}</td> <td>\dot{M}_2</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Er/hr</td> <td>1b/hr</td> <td>Identification</td> </tr> </table>	τ_{3R}	T ₂	V _{ex2}	\dot{M}_2	XXXXXXX	Hours	Hours	Er/hr	1b/hr	Identification
τ_{3R}	T ₂	V _{ex2}	\dot{M}_2	XXXXXXX							
Hours	Hours	Er/hr	1b/hr	Identification							
464	<table border="1"> <tr> <td>ΔV_{BR}</td> <td>τ_{2N}</td> <td>K_{p0}</td> <td>K_{y0}</td> <td>XXXXXXX</td> </tr> <tr> <td>Er/hr</td> <td>Hours</td> <td>Radians</td> <td>Radians</td> <td>Identification</td> </tr> </table>	ΔV_{BR}	τ_{2N}	K _{p0}	K _{y0}	XXXXXXX	Er/hr	Hours	Radians	Radians	Identification
ΔV_{BR}	τ_{2N}	K _{p0}	K _{y0}	XXXXXXX							
Er/hr	Hours	Radians	Radians	Identification							

TABLE A-II.- CARD FORMAT - Continued

Card no	Column
465 - 468	Same format as cards 461 - 464 except for same launch day and second opportunity
469 - 476	Same format as cards 461 - 468 except for second launch day
477 - 484	Same format as cards 461 - 468 except for third launch day
485 - 492	Same format as cards 461 - 468 except for fourth launch day
493 - 500	Same format as cards 461 - 468 except for fifth launch day
501 - 508	Same format as cards 461 - 468 except for sixth launch day
509 - 516	Same format as cards 461 - 468 except for seventh launch day
517 - 524	Same format as cards 461 - 468 except for eighth launch day
525 - 532	Same format as cards 461 - 468 except for ninth launch day
533 - 540	Same format as cards 461 - 468 except for tenth launch day
1 - 17	18 - 34 35 - 51 52 - 68 69 - 80
541	Launch day of year T_{LO} θ_{EO} ω_e XXXXXXXX
542	Hours Radians rad/hr Identification K _{α1} K _{α2} K _{T3} t _{DSO} XXXXXXXX rad/hr ² Hours Identification

TABLE A-II.- CARD FORMAT - Continued

Card no	Column										
543	1 - 17 18 - 34 35 - 51 52 - 68 69 - 80 <table border="1"> <tr> <td>t_{DS1}</td> <td>t_{DS2}</td> <td>t_{DS3}</td> <td>h_{10}</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Hours</td> <td>Radians</td> <td>Identification</td> </tr> </table>	t_{DS1}	t_{DS2}	t_{DS3}	h_{10}	XXXXXXX	Hours	Hours	Hours	Radians	Identification
t_{DS1}	t_{DS2}	t_{DS3}	h_{10}	XXXXXXX							
Hours	Hours	Hours	Radians	Identification							
544	h_{11} h_{12} h_{13} h_{14} XXXXXX <table border="1"> <tr> <td>t_{D1}</td> <td>t_{SD1}</td> <td>h_{20}</td> <td>h_{21}</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Radians</td> <td>Radians</td> <td>Identification</td> </tr> </table>	t_{D1}	t_{SD1}	h_{20}	h_{21}	XXXXXXX	Hours	Hours	Radians	Radians	Identification
t_{D1}	t_{SD1}	h_{20}	h_{21}	XXXXXXX							
Hours	Hours	Radians	Radians	Identification							
545	h_{22} h_{23} h_{24} t_{D2} XXXXXX <table border="1"> <tr> <td>t_{D1}</td> <td>t_{SD1}</td> <td>h_{20}</td> <td>h_{21}</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Radians</td> <td>Radians</td> <td>Identification</td> </tr> </table>	t_{D1}	t_{SD1}	h_{20}	h_{21}	XXXXXXX	Hours	Hours	Radians	Radians	Identification
t_{D1}	t_{SD1}	h_{20}	h_{21}	XXXXXXX							
Hours	Hours	Radians	Radians	Identification							
546	h_{22} h_{23} h_{24} t_{D2} XXXXXX <table border="1"> <tr> <td>t_{SD2}</td> <td>h_{30}</td> <td>h_{31}</td> <td>h_{32}</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Radians</td> <td>Radians</td> <td>Identification</td> </tr> </table>	t_{SD2}	h_{30}	h_{31}	h_{32}	XXXXXXX	Hours	Hours	Radians	Radians	Identification
t_{SD2}	h_{30}	h_{31}	h_{32}	XXXXXXX							
Hours	Hours	Radians	Radians	Identification							
547	h_{33} h_{34} t_{D3} t_{SD3} XXXXXX <table border="1"> <tr> <td>t_{SD2}</td> <td>h_{30}</td> <td>h_{31}</td> <td>h_{32}</td> <td>XXXXXXX</td> </tr> <tr> <td>Hours</td> <td>Hours</td> <td>Radians</td> <td>Radians</td> <td>Identification</td> </tr> </table>	t_{SD2}	h_{30}	h_{31}	h_{32}	XXXXXXX	Hours	Hours	Radians	Radians	Identification
t_{SD2}	h_{30}	h_{31}	h_{32}	XXXXXXX							
Hours	Hours	Radians	Radians	Identification							
548	Same format as cards 541 - 548 except for second launch day										
549 - 556	Same format as cards 541 - 548 except for third launch day										
557 - 564	Same format as cards 541 - 548 except for third launch day										

TABLE A-II.- CARD FORMAT - Concluded

Card no	Column
565 - 572	Same format as cards 541 - 548 except for fourth launch day
573 - 580	Same format as cards 541 - 548 except for fifth launch day
581 - 588	Same format as cards 541 - 548 except for sixth launch day
589 - 596	Same format as cards 541 - 548 except for seventh launch day
597 - 604	Same format as cards 541 - 548 except for eighth launch day
605 - 612	Same format as cards 541 - 548 except for ninth launch day
613 - 620	Same format as cards 541 - 548 except for tenth launch day

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4. Davis, Robert S.; and Lee, W. R.: AS-503/504 Requirements for the RTCC: The Return-To-Earth Abort Processor, Volume I - Earth-Centered Logic. MSC IN 67-FM-199, December 15, 1967.
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